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PATENT SPECIFICATION

DRAWINGS ATTACHED

927,075

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Improvements relating to pressure sensing devices and methods of manufacture of such devices.

COMPLETE SPECIFICATION

We, UNITED AIRCRAFT CORPORATION, a corporation organised and existing under the laws of the State of Delaware, United States of America, of East Hartford, Connecticut, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to fluid pressure sensing devices or transducers and more particularly to a fluid pressure transducer for sensing relatively small transient pressures, and to a method of manufacture of such pressure sensing devices.

It is an object of this invention to provide a fluid pressure transducer in the form of a fluid pressure sensing device which operates on an optical interference principle.

According to the invention, a fluid pressure sensing device adapted to intercept a light beam and reflect said beam with characteristics commensurate with the fluid pressure being sensed, comprises a yieldable outer diaphragm defining a partially transparent mirror and an inner reflective diaphragm disposed in spaced relationship, and a casing having a peripheral wall in fluid-tight relationship with the periphery of said outer diaphragm, said casing having an end wall joined to said peripheral wall in spaced relationship to said inner diaphragm and forming a chamber therewith, said chamber communicating with the space between said diaphragms and containing fluid at a predetermined pressure, lower than ambient pressure.

Also according to the invention. a method of manufacturing a fluid pressure sensing device having a casing including a base member and a cover member with a lip extending partially from the side wall thereof, comprises inverting said cover on a magnetic block, applying cement around the inside of said lip, inserting a partially reflective outer diaphragm in said cover in contact with said cement, inserting an annular spacer in said cover in contact with said diaphragm, inserting a second reflective diaphragm in said cover in contact with said spacer, placing said base member over said second diaphragm and connecting said base member and cover members in sealed relationship to form a peripheral wall in fluid-tight relationship with the periphery of said outer diaphragm and an end wall joined to said peripheral wall in spaced relationship to said second diaphragm and forming a chamber therewith, said chamber communicating with the space between said diaphragms, the assembly being completed in an atmosphere at a predetermined pressure, lower than ambient pressure.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawing in which:

Figure 1 is showing of the fluid pressure transducer partially in cross section and partially in schematic illustration;

Figure 2 is a schematic illustration of the impinging and reflected light beams of the pressure senser;

Figure 3 is a diagrammatic illustration of the operation of the senser;

Figures 4 and 5 are illustrations of the arrays of optical interference rings produced by the senser; and

Figure 6 is an enlarged detail of a portion of the senser illustrating the construction thereof.

As seen in Figure 1, a fluid pressure transducer or senser is generally indicated at 10 as having a casing comprising a base member 12 and a cover member 22 together supporting an outer and an inner diaphragm 14 and 16 respectively which are spaced apart to form a space 18. The diaphragms 14 and 16 are separated by an annular space 20

and are in turn fixedly clamped to the base 12 by the cover member 22. A beam of light rays directed towards the diaphragms from a source 26 is reflected from both the diaphragm members 14 and 16 so as to reflect an array or pattern of concentric rings whose characteristics can be visually noted or sensed by a photoelectric cell 30 in the path of the reflected beam. The photoelectric cell may be of the type designated by the Radio Corporation of America as 1 P 21 or another suitable photo-electrical transducer. The read-out of the photoelectric cell may be conducted to a suitable recorder 32 for reduction to any form of data. The photoelectric cell 30 may scan the diameter or radius of the transducer and produce impulses commensurate with the number of light or dark rings being transmitted in the reflected beam. These impulses can be suitably recorded by any well-known device.

The diaphragms 14 and 16 (Figure 2) are made of a normally transparent material such as glass and are suitably coated with reflective films so that the diaphragm 14 is semi-transparent while the inner diaphragm 16 is substantially a full mirror. With the space 18 between the diaphragms maintained at some predetermined pressure lower than ambient pressure any changes in pressure acting on the outer face of the diaphragm 14 will cause it to deflect inwardly with respect to its co-operating diaphragm 16. An impinging light ray 40 will be partially reflected by the semi-transparent surface 42 of the diaphragm 14 as a reflected beam 44. That portion of the light ray 40 that passes on through the diaphragm 14 is reflected by the surface 46 of the diaphragm 16 so that the reflected beam 48 is produced.

When there is an increase in external pressure on the outer face of the diaphragm 14 it will deflect as shown in an exaggerated form in Figure 3. As a result, an interference fringe pattern such as shown in Figures 4 and 5 is observed when the entire surface of the gauge is viewed. Each dark circle (destructive interference) is the locus of points at which the distance S (Figure 3) is a constant. S changes by 1/2 the length of a light wave in the interval between adjacent dark bands. Thus, the number of interference fringes appearing in the pattern is a function of external pressure. Therefore, it would be apparent that the pattern or array shown in Figure 4 is one for a relatively higher pressure being sensed than the pattern displayed in Figure 5.

In order to determine the sign as well as the magnitude of the external pressure change, the inner chamber or space 18 of the cell is partially evacuated. Then a pattern of interference fringes appears for ambient pressure and the fringe density increases for external pressures greater than ambient and decreases for external pressures less than ambient. Of course the outer diaphragm 14 is not permitted to pass through its zero deflection position since this would provide a fringe count which would be ambiguous. The internal pressure of the transducer, i.e., in space 18, should be slightly less than the lowest pressure to be measured. The full range of pressures which can be sensed by the transducer is determined by the thickness and/or stiffness of the diaphragms.

As best seen in Figure 6, the base member 12 forms a chamber 54 with volume relatively greater than space 18, adjacent the inner diaphragm 16 which is connected with the space 18 by a passage 56. The passage 56 forms a restriction between the space 18 and the chamber 54 and thus acts as a dashpot or restriction orifice to damp out or filter rapid changes in deflection of the outer diaphragm 14 relative to the diaphragm 16.

The pressure transducer or senser is constructed in a manner which permits it to be maintained substantially small in size and weight. Thus, a transducer has been made 0.3 inches in diameter which a thickness of 0.027 inches and having an over-all weight of 0.00027 pound. The diaphragms 14 and 16 are made from commercial microscope cover glass approximately 0.003 inches thick. The outside diameters of the diaphragms and the passage 56 are formed by an ultrasonic grinding process. The material is cut away by the action of abrasive particles impacted on the part at ultrasonic frequencies. The mirror coatings 42 and 46, respectively, are applied by high vacuum deposition. The inner diaphragm is coated at 46 with an opaque aluminium film yielding approximately 90 per cent reflectance, whereas the outer diaphragm is coated at 42 with a dielectric coating providing approximately 30 per cent reflectance and 70 per cent transmittance.

The spacers 58 and 20 (Figure 6) are made of 0.001-inches thick ground steel shim stock by a photoetching process. The base member 12 and the cover member 22 are machined from magnetic stainless steel.

Before assembly, the parts are washed in suitable agents such as xylene and methyl alcohol. The assembly is effected by use of a magnetic block arranged so that the work piece spans the poles of the magnet, thus holding the parts during fabrication. The cover member 22 is placed face down on the magnetic block and a minute quantity of epoxy cement (room temperature cure) is spread over the inside lip 62 of the cover member. The elements of the transducer are then placed in the cap in the proper order and the magnetic attraction of the base 12 draws all the components together. This also induces a small elastic deflection of the

relatively thin lip 62 of the cover member 22, as the lip 62 resiliently engages the outer diaphragm 14 through the spacer 58. Cement is introduced into the groove area 70 to bond the base 12 to the cover member. The entire unit may be placed in a suitable atmosphere having a pressure which is to become the predetermined datum in the chamber 54 and space 18. In this atmosphere, cement is used to block the vent 68.

When the entire device is removed from its magnetic assembly block, the elements are maintained substantially clamped firmly in place by the spring action of the deflected lip 62.

As a result of this invention a very accurate fluid pressure sensing device has been provided in the form of a miniaturized pressure transducer. The transducer is inherently insensitive to inertia forces such as accelerations due to the fact that it is only sensitive to the relative motion of the two diaphragms 14 and 16. Any inertial forces which may act on the transducer will affect both diaphragms to the same extent so that no relative motion is introduced in this manner.

The transducer is simple and light in weight, and the use of the optical interference principle eliminates the necessity for any electrical or mechanical connections to the senser.

Although one embodiment of this invention has been illustrated and described herein, it will be apparent that various changes may be made in the construction and arrangement of the various parts without departing from the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:

1. A fluid pressure sensing device adapted to intercept a light beam and reflect said beam with characteristics commensurate with the pressure being sensed, comprising a yieldable outer diaphragm defining a partially transparent mirror and an inner reflective diaphragm disposed in spaced relationship, and a casing having a peripheral wall in fluid-tight relationship with the periphery of said outer diaphragm. said casing having an end wall joined to said peripheral wall in spaced relationship to said inner diaphragm and forming a chamber therewith, said chamber communicating with the space between said diaphragms and containing fluid at a predetermined pressure lower than ambient pressure.

2. A pressure sensing device according to claim 1 wherein an annular spacer is interposed between said diaphragms.

3. A pressure sensing device according to claim 2 wherein said diaphragms are discs.

4. A pressure sensing device according to any one of the preceding claims, wherein said chamber has a volume exceeding that of the space between said diaphragms and communication therebetween is established through a restricted orifice.

5. A pressure sensing device according to any one of the preceding claims, wherein the peripheral wall of the casing has a lip extending from said peripheral wall and resiliently engaging said outer diaphragm.

6. A pressure sensing device according to any one of the preceding claims, wherein said outer diaphragm is more transparent and less reflective than said inner diaphragm.

7. A pressure sensing device according to any one of the preceding claims, including a light source for directing a light beam towards said diaphragms, light sensing means in the path of the beam of light reflected from said diaphragms, and indicating means responsive to said light sensing means.

8. A method of manufacturing a pressure sensing device having a casing including a base member and a cover member with a lip extending partially from the side wall thereof, comprising inverting said cover on a magnetic block, applying cement around the inside of said lip, inserting a partially reflective outer diaphragm in said cover in contact with said cement, inserting an annular spacer in said cover in contact with said diaphragm, inserting a second reflective diaphragm in said cover in contact with said spacer, placing said base member over said second diaphragm and connecting said base member and cover member in sealed relationship to form a peripheral wall in fluid-tight relationship with the periphery of said outer diaphragm and an end wall joined to said peripheral wall in spaced relationship to said second diaphragm and forming a chamber therewith, said chamber communicating with the space between said diaphragms, the assembly being completed in an atmosphere at a predetermined pressure, lower than ambient pressure.

9. A pressure sensing device substantially as hereinbefore described with referenc to the accompanying drawing.

10. A method of manufacturing a pressure sensing device substantially as hereinbefore described with reference to the accompanying drawing.

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927,075 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

FIG. 1

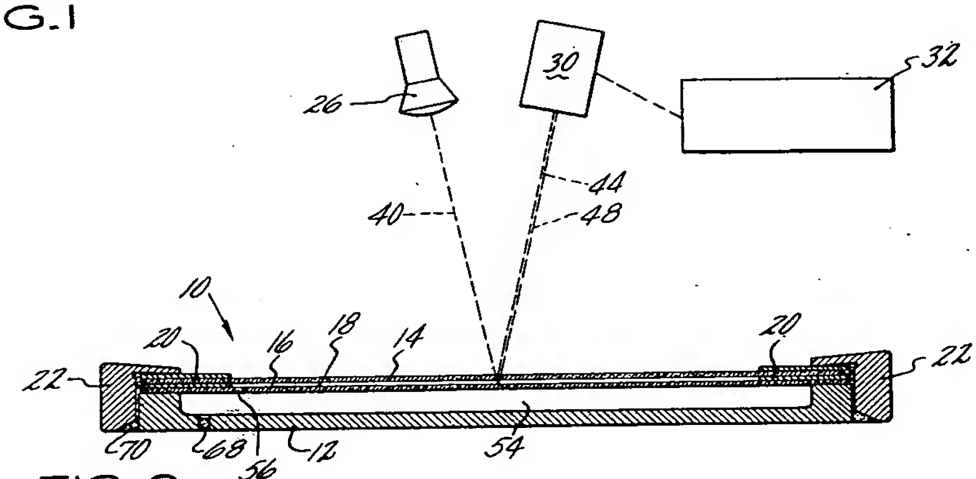

FIG. 6

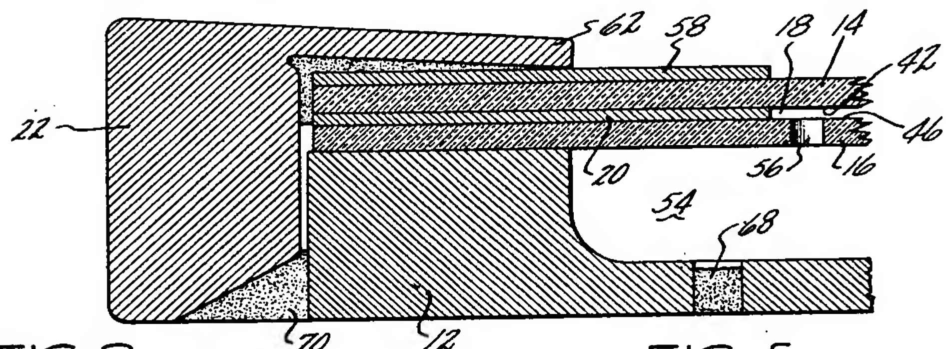

FIG. 2

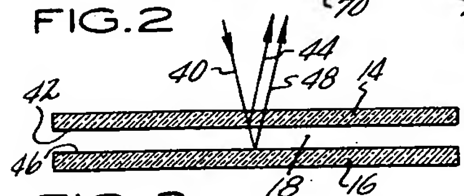

FIG. 3

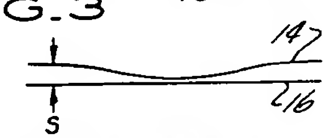

FIG. 4

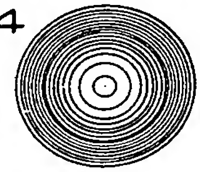

FIG. 5